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Reestablishment and Use of Grass in the Morton County, Kansas, Land Utilization Project

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Highlights

This technical paper reports the results of land stabilization and grass reestablishment, management, and use in the Morton County, Kans., Land Utilization Project. The work was undertaken when wind erosion was a critical problem, there was little information on how to reestablish grass, and no seed was available.

These pioneering efforts and the results attained provided information that has been widely used in the central and southern Great Plains as a guide to stabilizing land and reestablishing permanent vegetation. Some of the significant results are--

1. The work on this project has demonstrated that cropland and denuded rangeland can be successfully reestablished in native range grasses--the use to which much of this land is best suited.
2. Forage sorghum or broomcorn is the crop most effective in initial stabilization; if mowed before seeds mature, it provides a good ground cover or mulch in which to plant grass.
3. A grass drill with a specially designed seedbox, double-disk furrow openers, and depth-control bands is the best tool with which to plant grass seed with a minimum of disturbance to the mulch or seedbed. If seed cannot be drilled and is broadcast, covering the seed improves the chances of getting a stand. The success of airplane seeding is greatest where done on one-wayed ground and where seeding is followed by disking to cover the seed.
4. Only seed of local origin or proved adaptation to the locality and site can be expected to persist and perform well in permanent rangeland seedings. Sand bluestem, little bluestem, sideoats grama, and sand lovegrass are the best grasses for seeding sandy land. Blue grama, sideoats grama, and buffalograss are best for hard land.
5. The optimum time for planting these grasses is February and March.
6. A rate of seeding that provides 15 to 20 pure live seed per square foot is adequate. Thirty percent of the pure live seed planted can be expected to result in seedling plants.
7. Planting with a grass drill in weed cover on stabilized fields resulted in more stand failures than planting in sorghum residue. It is not possible to predict the kind of weed growth and competition to expect on these fields.
8. Four of six trial plantings in sand sagebrush were successful, but the use of drills in this kind of cover without previous treatment of the land is impractical. Of several methods tried, one-waying was the most effective in reducing sand sagebrush and in providing a seedbed for drilling grass.
9. Seedings of native grasses need to be protected from grazing for 2 years or more after seeding. Then use must be controlled to maintain plant vigor and the stocking rate must be adjusted to meet the fluctuations in forage production characteristic of this climate.

REESTABLISHMENT AND USE OF GRASS IN THE MORTON COUNTY, KANSAS, LAND UTILIZATION PROJECT

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The Morton County Land Utilization Project is one of several similar projects established early in the 1930's as part of a program to remove some hazardous land from crop production and reestablish it in grass. From 1938 to 1954 the Soil Conservation Service administered this project. Since 1954 it has been administered by the Forest Service and is now known as the Cimarron National Grassland District of the San Isabel National Forest.

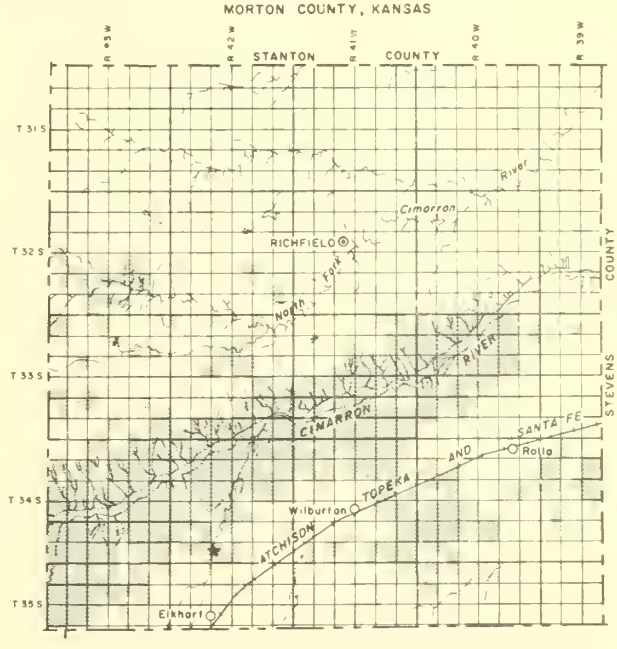
When this project was started, little was known about how to reestablish native range grasses in this semiarid part of the Great Plains. It was necessary to try many different kinds of seedbed preparation and methods of seeding. Not all were successful but some were, and grass was reestablished on nearly all the 107,000 acres in the project. This paper relates the methods used, the results obtained, and the procedure used to develop the area for livestock grazing.

Description of the Area

Location and size

Morton County is in the extreme southwestern corner of Kansas and is bordered by Colorado on the west and by Oklahoma on the south. The project itself straddles the Cimarron River, which is considered to be the dividing line between the southern and the central High Plains. Land in the project is representative of a large surrounding area in Kansas, Colorado, Oklahoma, Texas, and New Mexico.

The size of the project varied with the acquisition and exchange of land. The first purchase in 1935 encompassed 53,590 acres. In 1938 an additional 42,800 acres was purchased. Other acquisitions and exchanges were made in an attempt to block the project into the best possible management unit. By 1942 the project consisted of 107,000 acres, and it has remained nearly the same size.



Land of Morton County in land-utilization project is shown by shaded areas, project headquarters by star.

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History

Before Morton County was organized in 1886, the area was a hunting ground for Kiowa and Comanche Indians, a pathway for the Santa Fe Trail, and an open range for cattle. The leg of the Santa Fe Trail known as the Cimarron Cut-off crossed what is now Morton County. This part of the trail was considered dangerous by even the most experienced trail drivers because of the dry crossing from the Arkansas River to the uncertain waters of the Cimarron and because Indians made frequent attacks from the surrounding sandhills. From 1861 to the close of the Civil War, the Cimarron Cut-off was considered too dangerous to use.

Cattle were first driven into this country in 1872. They were brought northwest around Indian territory and then back down the Arkansas River. In about 1875 cattle began coming in from the south, many going to the market at Dodge City. By 1880 ranchers claimed all the land between Dodge City and the Colorado line. Usually they owned only the land on which their headquarters and watering places were located. Their cattle roamed the open range--the herds of one mingling with those of others. This era of the cattleman was relatively short. The homesteader, barbed wire, and the blizzard of '86 virtually spelled the end of it.

Homestead settlement began with all the optimism characteristic of the expanding times. In 1888 there were 2,618 people in the new county. These settlers were poorly prepared for the conditions they were to face during the dry years that followed, and many of them returned to the East. Not until 1920 was the population again as large as in 1888.

Trial and error have long been the educators in Morton County. Harvested corn acreage in 1888 was more than 14,000. For the last 10 years corn has been harvested from less than 1,000 acres annually. With the development of varieties of grain and forage sorghums adapted to this area, the acreage in sorghum increased from 2,400 during the first 10 years of settlement to 115,000 in 1959. The acreage of broomcorn remained fairly constant at about 12,000 until recent years when it dropped off sharply.

Wheat has been the great fluctuator--the big moneymaker and the great heartbreaker. Production has ranged from a high of 2,700,000 bushels in 1948 to total failure in 1937 and 1938. Exceptionally high yields produced bumper crops in 1926, 1931, 1947, and 1948. Good years and the accompanying high returns have come just often enough to make wheat the most popular cash crop.

Climate

Morton County is in an area described by Thornthwaite as semiarid. There is little or no water surplus in any season of the year. The average annual precipitation for 1891-1960 at Richfield is 16.77 inches. But the precipitation extremes, from a high of 32.88 to a low of 7.09 inches a year, are much more significant than the average annual precipitation. The longest successive period of below-normal rainfall was 1931-40 when rainfall averaged 11.17 inches annually. The longest successive period of above-normal rainfall was 1927-30 when rainfall averaged 20.43 inches annually. Frequent severe droughts make production of cultivated crops hazardous.

About three-fourths of the annual precipitation occurs from April through September. This is the growth period of warm-season grasses, such as sand bluestem and blue grama, which are the important grasses in this area. Snowfall averages 18 inches per year, and the ground has snow cover for about 20 days a year. Snow supplies little effective moisture to most of the area because it is usually accompanied by high winds and much of it drifts into valley and draws.

Sunshine and high winds are the two most impressive climatic factors. Dodge City weather records show that the sun shines 70 percent of the time it is above the horizon and that the average annual wind velocity is 15 miles per hour. Monthly wind velocities range from 17.3 miles per hour in March to 13.6 miles per hour in August. These winds are responsible for the high rate of evaporation and transpiration, and they increase the hazard of dust storms on land not well protected by permanent plant cover.

The average length of the growing season is 180 days, April 23-October 20. The relatively high elevation (3,150 to 3,700 feet), low humidity, and constant air movement give this area a pleasant summer climate.

Soils

Most of the project area is land lying adjacent to and including the Cimarron River Valley. This valley averages little more than one-half mile in width and consists mostly of sandy soils in the Lincoln series. These soils are not suitable for use as cropland because of periodic flooding, deposition, and stream-channel shifting.

The upland soils on the part of the project lying south of the river have developed from wind-blown sands on strongly hummocky to billowy topography. They are sands and sandy loams in the Tivoli, Vona, and Dalhart series. The Dalhart soils are productive either as cropland or rangeland. The Vona soils are well suited to use as rangeland but have limited suitability for use as cropland. The Tivoli soils are suitable only for use as rangeland.

The project also includes most of the nonarable steep or broken slopes bordering the Cimarron River on the north. Silty soils in the Colby and Potter series, suitable only for rangeland, are dominant. A few isolated sections and quarter sections consist of

nearly level to gently sloping tableland north of the river. These deep silty soils of the Richfield and Ulysses series are suitable for use as either cropland or rangeland.

Range sites

Range sites are kinds of rangeland that differ from each other in their capability to produce significantly different kinds or amounts of native vegetation. If the original plant cover is gone, climate, kind of soil, and topography must be used to identify range sites.

All the rangeland is in the 15- to 19-inch rainfall belt. Differences in the kind and amount of potential plant cover place it in seven range sites. For this report the minor amounts of lowland and saline lowland are ignored, and the five upland sites are grouped as follows:

GROUP	RANGE SITE	SOILS
Hard land	Loamy upland	Colby silt loam
		Richfield silt loam
		Ulysses silt loam
	Breaks	Potter series
Sandy land	Sandy	Dalhart fine sandy loam
		Vona fine sandy loam
	Sands	Dalhart loamy fine sand
		Tivoli loamy fine sand
		Vona loamy sand
	Choppy sands	Tivoli fine sand

The major range site in the hard-land group is loamy upland. The principal climax grasses are blue grama, buffalograss, western wheatgrass, sideoats grama, and little bluestem. Buffalograss is the principal increaser under grazing pressure. Blue grama and buffalograss are the dominant grasses under present grazing use. Annuals are the principal invaders. With average rainfall, this site in excellent condition annually produces 1,250 to 2,000 pounds of forage per acre.

The major range sites in the sandy-land group are sandy and sands. The principal climax grasses are sand bluestem, little bluestem, sideoats grama, and switchgrass. These climax dominants may make up 55 to 65 percent of the plant composition and perennial forbs and grasses the rest. The dominant increaser grasses are blue grama, sand dropseed, and sand paspalum. Sand sagebrush is the principal woody increaser. With average rainfall, these sites in excellent condition annually produce 1,500 to 2,500 pounds of forage per acre.

Wind-erosion damage on sandy land at time Government purchased land for project.

Land use and erosion

Land in Morton County is subject to both wind and water erosion. Because of low rainfall and frequent droughts, the hazard of wind erosion is especially severe. Land use is the determining factor in erosion control. Erosion is effectively controlled on well-managed rangeland that is protected by a permanent plant cover. Overgrazing and dust deposits from adjacent cropland may kill vegetation and leave rangeland open to severe damage by wind.

Generally, sandy land is low in organic matter, silt, and clay, which are necessary for the formation of wind-resistant soil aggregates. When wind erosion occurs, more of these fine materials are removed.

Both sandy land and hard land were seriously damaged by the wind erosion that followed the years of drought and crop failure early in the 1930's. By 1938 more than 78 percent of Morton County had been affected by serious wind erosion. Much of the area was covered by moving dunes or was swept bare by shifting sand.

Land-utilization program

By 1935 wind erosion in the Great Plains had reached such magnitude that national attention was focused on the problem. It was apparent that much

Wind-erosion damage on denuded native hard-land pasture.

land in cultivation was not suited to continued crop production. Not only did this land fail to produce but it was damaging surrounding land. The economy of the whole area was affected.

In 1935 Congress authorized the use of relief funds for the purchase and retirement of such land. The program was administered first by the Resettlement Administration and then by the Bureau of Agricultural Economics. In November 1938 under new legislation (Title III of the Bankhead-Jones Farm Tenant Act), the land-utilization program was transferred to the Soil Conservation Service for administration.

The objective of the land-purchase and land-use-adjustment program was threefold: First, to restore the land to its best suited use; second, to use it so that its productivity is maintained or improved; and third, to use it so that it contributes to a sound, permanent agricultural economy for the area.

The Soil Conservation Service administered the Morton County project during the period of restoration to grass. On January 1, 1954, the Secretary of Agriculture transferred the land-utilization program to the Forest Service, and the project was renamed the Cimarron National Grassland District of the San Isabel National Forest. George Atwood, Elkhart, Kans., was the resident manager from 1938 to 1962.

What Was Done To Establish Plant Cover

Temporary stabilization

One-third of the land acquired by the Federal Government had been cropped, and most of it was unstable and blowing. Part of the rangeland, particularly the hard land, was bare and subject to erosion. The first job was temporary stabilization. Fences were taken up and farmstead buildings cleared away so that soil drifts could be leveled. The land was then listed with farm listers, which on hummocky land were pulled by crawler tractors. This work progressed the year round except when the ground was frozen. From May through July, the land was listed and planted at the same time for more effective stabilization. A forage sorghum (most commonly Black Amber cane) and broomcorn were used in these stabilization plantings because they produced growth slow to deteriorate and were more apt to reseed the following year than other forages.

Abandoned field that has been blank listed.

In the fall rye was drilled on some land previously listed, but it was not so effective as listed cane or broomcorn. It was usually necessary to list and plant the most severely eroded fields two or three times.

As soon as a stable cover was obtained, tillage was discontinued and natural plant succession was allowed to take place. Not until 1940, 5 years after the first land purchases, did the temporary stabilization program reduce the blow area to less than 1,000 acres. As this point of temporary stabilization was reached, attention was given to seeding permanent grasses.

Trial plantings of perennial grasses

SEEDBED PREPARATION

In 1939 when the first permanent plantings were made, little information was available on methods of preparing a seedbed for perennial grasses. It was obvious that there must be some natural vegetation or crop residue to protect the soil and young grass seedlings. Representatives of State experiment stations and the Soil Conservation Service together planned and started plantings on both a plot and a field scale. The trial plantings were made by the SCS Nursery Division, and the results were studied and evaluated for several years.

The first plantings were small and on selected sites where seedbed conditions were thought to be adequate. Plantings were made in four kinds of seedbed: (1) Weed cover mostly russianthistle, (2) weed cover mostly pigweed, (3) sand sagebrush, and (4) wheat stubble.

Grass stands were obtained on only some of the plantings made in wheat stubble and sagebrush. The seedings in weed cover failed. Because of these disappointing results, little planting was done in 1940. Instead, plans were made for planting trials in carefully prepared or selected seedbeds. These trial plantings made annually through 1945 provided the basis for the field-scale seeding methods used later.

On sandy land, plantings were made in three kinds of seedbed: close-drilled forage sorghum, weed cover, and depleted rangeland supporting sand sagebrush. On hard land, plantings were made only in forage sorghum and weed cover.

Forage sorghum.--These field trials showed that a close-drilled forage sorghum mowed before seed development provides the best seedbed for seeding native grasses. Broomcorn or sudangrass are satisfactory substitutes for Black Amber cane or other local varieties of forage sorghum. The land was tilled with a one-way or a heavy-duty disk. The cover

Partially mowed field of close-drilled sorghum. Soil has been stabilized and field is to be seeded to grass the next spring.

Native grasses holding a sandy nursery plot that had been seeded in a weed cover the year before.

crops were planted with grain drills in 12- or 14-inch rows in June or July. In late summer as the crop began to head, it was mowed at about 12 inches with tractor-mounted power mowers equipped with a caster wheel that supports the outer end of the cutter bar at this height. All the forage was left on the ground. In years of unusually good moisture and on tracts of productive soil, this system produced a little too much residue for the best planting conditions, but these years were the exception. Usually soil fertility and moisture conditions were such that about the right amount of cover was produced to give good soil protection and permit planting with a grass drill.

Weed cover.--The trial-planting results showed that grass plantings can be made successfully in some kinds of natural weed growth without preparing a seedbed. The most consistently successful plantings in weed cover were those made in a thick, stunted growth of russianthistle or annual sunflower in fields that had not been tilled for 3 years or more. The soil surface was firm and there was some protection against erosion and only moderate competition from weeds. Some weeds were too competitive for successful establishment of native-grass seedlings. Where there was a thick growth of sandbur, puncturevine, camphorweed, horseweed, western ragweed, wild lettuce, or blueweed, many seedings failed and it was necessary to grow a crop of sorghum first to provide a seedbed for grass.

The problem in seeding into a weed cover is the difficulty of predicting the kind of weeds that will grow on a particular field the next year. Therefore, failures are more common in weed cover than in forage sorghum.

Sand sagebrush.--Another kind of natural seedbed used in the planting trials on sandy land consisted of depleted ranges where the dominant vegetation was sand sagebrush. From 1940 to 1945, four of six planting trials made by drilling into sagebrush with no previous tillage were successful. One of the two failures was attributed to grasshopper damage.

In 1943 a field-scale planting of more than 160 acres was made in sagebrush. It too was successful. But seeding in this kind of land without any previous treatment is so slow and so damaging to grass drills that it was impractical for field-scale operations.

This led to trials of different methods of eradicating or controlling sand sagebrush. Mowing had proved effective on sagebrush rangeland at the U.S. Southern Great Plains Field Station at Woodward, Okla. Plot tests were made on the Morton County project to compare mowing, railing (with a heavy steel I-beam), and one-waying as methods of reducing sagebrush and preparing a seedbed for grass seeding. One-waying was the most effective in reducing sagebrush and other perennial vegetation. It also did the most complete job of leveling to permit operation of planting equipment. I-beam railing did a fair job of leveling and breaking down old sagebrush, but it killed very little sagebrush or other perennial vegetation. Mowing when root reserves were low was effective in controlling sagebrush, but without leveling much of this land was still too hummocky for satisfactory operation of grass-planting equipment. On the basis of these trials and field experience, one-waying was the method used to prepare most of the sand-sagebrush-covered sandy land for grass seeding.

GRASS MIXTURES SEEDED

When seeding was begun, little native-grass seed was available. Enough seed was obtained to make up what was thought to be a proper mixture for the nursery trial plots. On sandy land, the mixture consisted of blue grama, sand lovegrass, sideoats grama, little bluestem, and sand bluestem. On hard land, the mixture consisted of blue grama, sideoats grama, and buffalograss. Seed supplies of little bluestem, sand bluestem, and sideoats grama were so limited that they were not included in the mixture in some of the trial plantings. Since seed supplies of blue grama, buffalograss, and sand lovegrass were adequate, one or more of these grasses usually made up more than 75 percent of the mixtures.

Several other species were used in the initial trials. Weeping lovegrass, for example, was used in the first seedings, but seedling loss was heavy because of summer drought and winter temperatures. Weeping-lovegrass plantings in 1939 and 1940 showed a 75- to 100-percent loss during the first winter. Plants that survived persisted for several years. This exotic grass, aggressive in the seedling stage, has no place in mixture with native grasses. Sand dropseed also is too competitive, so it was eliminated from mixtures and used only to seed critical areas.

Other grasses included in trials that failed or showed little promise were Indian ricegrass, needle-andthread, green needlegrass, indiangrass, switchgrass, caucasian bluestem, El Kan Turkestan bluestem, big bluestem, intermediate wheatgrass, and tall wheatgrass. Usually, local-source seed of the native grasses was not available. Seed of distant origin was used, and this contributed to the failures. In some of the first trial plantings, good initial stands were obtained with crested wheatgrass, western wheatgrass, and Canada wildrye. Consequently, these three grasses were used to seed several thousand acres for several years. Crested wheatgrass and Canada wildrye persisted for only a few years. Western wheatgrass persisted only in swales or other areas of favorable moisture.

SEEDING RATES AND DATES

Three seeding rates were compared in the nursery planting trials. Rates of 10, 15, and 20 pounds of bulk seed per acre were used in 1940 and 1941. On the basis of stands obtained, rates were reduced to 5, 10, and 15 pounds per acre in 1942-45. The number of pure live seed per square foot was not closely controlled as it would be today. About 20 pure live seed per square foot on sandy land and 30 on hard land was the objective in using the heavy rate. Frequently, this goal was exceeded because of the high proportion of blue grama and sand lovegrass in the mixture. Seedlings counted the fall after planting ranged from zero to 100 percent of the pure live seed planted. More commonly the stands obtained represented 20 to 50 percent of the pure live seed planted. If on the average 30 percent of the pure live seed planted survives, a rate of 15 to 20 pure live seed per square foot gives 4.5 to 6 plants per square foot, which is enough for a good stand of grass. This was the basis for the planting rates in later field seedings.

Planting dates were not compared in the nursery trials. Since the mixtures consisted of only warm-season grasses, they were planted between April 15 and May 1. Later field plantings showed that better first-year stands and better seedling survival were obtained by planting earlier in the spring. This was particularly true of native-grass mixtures that contained a large proportion of dormant seed. It was first noticed in sand lovegrass for which a "quick" germination of less than 10 percent is common. It is similarly true of little bluestem, sand bluestem, and switchgrass. Because of this, the planting season was extended to include March and, if weather conditions permitted, January and February. Temperature and moisture conditions that germinate warm-season grasses usually occur during April. Germination is better if seed has been in the ground 6 weeks or more before then. It is important to get germination and seedling emergence as early as possible and to get seedlings well rooted before competitive weeds start to grow and before periods of summer drought. Studies of a 1941 sandy-land planting showed that roots of seedlings emerging April 28 had penetrated to the following depths by June 6: Blue grama, 7.5 inches; sideoats grama, 8.5 inches; and sand bluestem, 9 inches. Temperatures and soil-moisture conditions were exceptionally favorable. Other studies at the end of the first growing season showed that roots of the same species had penetrated to 30, 33, and 42 inches.

Good stand of grass 1 year after seeding in a sorghum-stubble seedbed. Seed mixture consisted of buffalograss, blue grama, sideoats grama, and sand dropseed.

Excellent stand of native grass 1 year after seeding in sorghum-stubble seedbed.

Crested wheatgrass 1 year after seeding in rye cover on hard land.

SEEDING METHODS AND EQUIPMENT

The first planting in 1939 was made with special grass drills equipped with single-disk furrow openers, cottonseed boxes for trashy seed, and a small fluted feed box for fine seed. Since seed tubes from the fine-seed box simply dropped the seed on the ground surface, it was used only for small seeds such as sand lovegrass, weeping lovegrass, and sand dropseed. The row spacing on these drills was 12 inches. The single-disk openers did not give satisfactory depth control, and in 1940 they were replaced by double-disk openers with depth bands to allow a maximum planting depth of 1 inch. This was the only important change made in these first grass drills. They and others patterned after them were used throughout the seeding program.

In the Nursery Division trials, drilling was compared with broadcasting and covering and with broadcasting without covering. The seed was broadcast by a grass drill having the furrow openers suspended so that they did not go into the ground. The seed was covered after broadcasting by going over the plots again with either a grass drill or a single disk set without pitch. The grass stands obtained from broadcasting without covering were inferior from the outset, and this method of planting was discontinued in later trials (table 1). The stands obtained from broadcasting and covering the seeds were nearly equal to

TABLE 1.--Initial stand of grass seedlings by number of plants per square meter [Plantings made on April 15, 1941, and stand counts on June 17, 1941]

Seedbed condition	Seed drilled	Seed broadcast and covered	Seed broadcast and not covered
Weed cover.....	31	27	25
Sudangrass.....	14	22	7
Broomcorn.....	14	19	8

Grass drills specifically designed for seeding native grasses in crop stubble. Lister hitch makes it possible for one tractor to pull the two drills.

those from drilling, and this method was used on a large acreage of field-scale planting. The results were best in years of exceptionally favorable moisture. Broadcasting, however, gives neither the uniform distribution nor placement of seed that is obtained from drilling.

MANAGEMENT OF STANDS DURING ESTABLISHMENT

Some of the early plantings were mowed during the first growing season to reduce weed competition. This was of some benefit to new grass seedlings, but it was not possible to mow regularly the large acreage seeded. No attempt was made to control insects although the loss of several stands was attributed to grasshopper damage.

No plantings were grazed for 3 years after planting, and some were rested as many as 7 years before grazing was begun. This allowed new grass stands to thicken and plants to become vigorous.

Field-scale seeding of perennial grasses

As soon as results of the trial plantings indicated the best seedbed conditions, seed mixtures, and seeding methods to use, the planting program was accelerated. Plantings through 1941 had totaled only 1,200 acres. In 1942 plantings were made on 2,500 acres, nearly all in a sorghum-stubble seedbed. In 1943 a goal of seeding 10,000 acres annually was established. With the limited funds available it was impossible to meet this goal and use the kind of seedbed preparation, planting method, and date of seeding that field trials indicated were best. One of the principal problems was an inadequate supply of seed of adapted native grasses.

In an effort to get more seed, some spaced-row plantings were made. The first was a 7-acre planting of pieces of sand bluestem sod taken from the railroad right-of-way southwest of Elkhart. This method required too much labor and time, and the planting was expanded later by a seed planting. This 25-acre planting and a second one of about the same size

Sand bluestem planted in 36-inch rows and intertilled for seed production. In 1943 this 7-acre field produced 1,778 pounds of seed.

provided the only seed of adapted-source sand bluestem available for later plantings. Other spaced-row plantings were made of El Reno sideoats grama, El Kan Turkestan bluestem, caucasian bluestem, crested wheatgrass, Canada wildrye, intermediate wheatgrass, tall wheatgrass, indiangrass, buffalograss, and sand lovegrass. The row plantings were intertilled and some were fertilized. Because of inadequate moisture, most of them produced little or no seed. Exceptions were sideoats grama and sand lovegrass. Some sideoats grama seed of fair quality was harvested, but the El Reno strain is not well suited to this area. Only sand lovegrass produced good seed yields. A 160-acre field planted in 20-inch rows with seed originating at Woodward, Okla., produced a good seed crop for several years. This seed and seed harvested from some of the new field plantings provided an abundance of sand lovegrass seed. For this reason in mixtures for sandy land, sand lovegrass was substituted for some of the more desirable species for which seed was lacking.

SEED MIXTURES

Warm-season grasses.--Of the total seeding of about 85,000 acres, about 75 percent was of warm-season grass mixtures. Seed mixtures varied widely because of the limited supplies, most of which were harvested from natural grassland. Beginning in 1941 blue grama and buffalograss seed was harvested in northwestern Kansas (Wallace and Greeley Counties) and eastern Colorado. In 1943 blue grama seed was harvested in central Kansas (Ness and Reno Counties). Much of the blue grama seed was of average or low quality, and in some the proportion of pure live seed was as low as 5 percent. Plants from seed originating too far north and at higher elevations showed little vigor in this area.

Not until 1946 was an abundance of high-quality blue grama seed available. In 1946 more than 90,000 pounds of blue grama seed was obtained from near Plainview, Tex., about 200 miles south. This seed was of high quality, averaging between 30 and 50

This 160-acre field of sand lovegrass that was planted in 24-inch rows and intertilled produced much of the sand lovegrass seed used on the land-utilization project.

percent pure live seed. It gave very good performance although it was planted more widely than it should have been because of the lack of seed of sand bluestem, little bluestem, sideoats grama, and western wheatgrass. Some seed of little bluestem, big bluestem, and sideoats grama harvested in central and eastern Kansas, Oklahoma, and Texas was planted, but much of it performed poorly here.

In an attempt to meet the annual reseeding goal 1,000 acres, mostly in isolated tracts that could be grazed separately, was planted to johnsongrass each summer for several years. This grass provided good summer grazing if the stands were maintained by tillage at the beginning of alternate growing seasons. Because of the difficulties of tilling this land, planting of johnsongrass was discontinued after about 4,000 acres had been planted.

Cool-season grasses.--To further extend the planting season, 1,000 acres was seeded to cool-season grasses in the fall. Cool-season grasses were seeded for several years. Some seedings were of crested wheatgrass alone, but most seedings consisted of a mixture of one-third each (bulk-seed basis) of crested wheatgrass, western wheatgrass, and Canada wildrye. Plantings were made on both hard land and sandy land, mostly in weed or other natural-cover seedbeds. No attempt was made to isolate pastures of cool-season grasses from spring-planted pastures of warm-season grasses. The patchwork pattern of cool-season and warm-season grass plantings of many different ages and degrees of establishment later presented many problems in grazing use and management. Livestock concentrated on certain tracts and, under this kind of use, crested wheatgrass usually did not survive for more than 5 years even where moisture conditions were favorable. Canada wildrye

was short lived. The fact that seed harvested in North Dakota was used may also have had a bearing on its lack of persistence. A few years after seeding, these cool-season grass plantings consisted mostly of western wheatgrass.

SEEDING METHODS

Drilling.--Earlier trials had shown that drilling with specialized grass drills was the best method of planting, but usually only five or six of these drills were available. Ordinary grain drills plant some grasses properly, and they were used to seed some of the cool-season mixtures. By making maximum use of the available drills, it was still not possible to meet the annual reseeding goals and other seeding methods were used.

Broadcasting and covering.--Most of the broadcast-and-cover planting was done with seed hoppers mounted on the rear of a crawler tractor. An oil barrel was used as a hopper for chaffy seed and a separate box for fine seed. Seed from the hoppers fed on to a revolving wheel that scattered the seed in a strip behind the tractor. A 20-foot single disk set with a little pitch was pulled behind the tractor to give some seed coverage. Because the seed was spread unevenly and was not well covered, this method was used only on rough land where it was difficult to operate a drill.

Airplane seeding.--In a further attempt to complete the seeding, about 18,000 acres was seeded by airplane in the winters of 1949-50 and 1950-51. About 2,000 acres of sandy-land range, consisting mostly of sand sagebrush, was one-wayed in the summer of 1949 to kill sagebrush and reduce competition for the seeded grass. Sand lovegrass seed was broadcast by airplane at a rate of 2 pounds per acre on December 22, 1949. The winter and spring that followed were extremely dry, and the overall stand obtained was poor. Because the seed was distributed poorly, the grass stand was only in the center of the flight strip. For the field as a whole, the seedling stand was about one-half plant per square meter. On a trial strip, several methods of treatment before and after planting were compared. Where the land was one-wayed, seed broadcast, and a disk pulled over the strip, the initial stand was 7.1 grass seedlings per square meter. Where no attempt was made to cover the seed, the stand was 4.7 plants per square meter.

In 1950, 16,000 acres of sandy land having different degrees of natural cover were one-wayed and seeded by airplane the following winter. The seeding was done by contract at a cost of $1.00 per acre and the Government furnished the seed. A flight-strip spacing of 66 feet gave uneven distribution of the 2½ pounds of sand lovegrass seed per acre. The overall stand was poor even though the initial stand was good on dunes and other spots nearly free of competitive growth. Although airplane seeding was inexpensive and very fast, it was not effective in establishing sand lovegrass unless the seedbed was well prepared and the seed covered.

SEEDING CRITICAL AREAS

One of the most difficult problems was working out a practical method for seeding the 35,000 acres of sands and choppy sands bordering the south side of the Cimarron River Valley. Although this rangeland had never been cropped, it had been denuded of desirable grasses by drought and grazing. The cover was mostly sand sagebrush, sand dropseed, and sand paspalum. It seemed inadvisable to plow this land and establish a sorghum cover crop as was the practice on less erodible land. On the basis of trial results with one-waying, railing, and mowing, it was decided to one-way most of this land with a large-disk one-way that barely cut the surface of the ground. The cut was just below the crowns of the sagebrush and perennial grasses, which left the plant residues on the surface for protection against erosion. The principal dune tops were avoided. The one-waying was done in late summer and fall, and the areas were seeded with a grass drill the following winter and spring.

This method reduced competition from brush and perennial grasses so that seedlings could become established. Although it did not provide the most desirable planting conditions, it put the land in condition to be planted with a grass drill. This method was used from 1946 to 1951 without causing any serious wind erosion. The grass stands were fair but not equal to these obtained where a seedbed could be properly prepared.

What Was Done in Management and Use

By 1943, 5 years after trial seeding was started, grass was well enough established that some of this land could be leased for grazing. In 1944 the Morton County Grazing Association was organized. This organization of local people then leased a certain amount of grazing from the Government and decided how grazing would be issued. The Government annually determined the number of animal units of grazing for each pasture and the length of the grazing season.

The grazing association also is responsible for maintaining water developments and fences and for distributing salt and livestock. It employs the number of range riders necessary to do this job and establishes living quarters for these men at appropriate locations on the project.

Range development

As additional land was reestablished in grass, grazing use and management plans had to be de-

veloped to maintain or improve the productivity of this grazing land indefinitely. Facilities had to be installed so that grazing animals could utilize the area and so that grazing use could be controlled.

It was necessary to completely rework the pattern of fences and water developments for livestock. Three hundred miles of deteriorated unusable fence was removed, and 214 miles of new fence was built. Now 348 miles of standard four-wire fence with posts 20 feet apart divides the project into desirable management units.

It was possible to reclaim only seven wells. Seventy-five new wells were installed as needed to bring about proper distribution of cattle. Wells are so located that cattle do not have to travel more than $1\frac{1}{2}$ miles to water and no more than 100 head of cattle water at any one installation. This is an important factor in proper distribution of grazing. At the start of the grazing season, the range riders divide and group cattle around each watering place and redistribute them during the grazing season if necessary.

Range management

Range seeding has no lasting value unless the range is used and managed properly after it is reestablished. Sound range management is accomplished through proper use of the key range plants and proper season of use by the kind of livestock best suited to the particular kind of range.

PROPER FORAGE USE

If one management factor can be singled out as most important, it is proper use of the forage plants. This is attained when no more than a specified amount of the current annual growth, usually 50 percent, is removed by the end of the grazing period. Leaving some grass at the end of the season--about half the amount produced that season--provides protection to the soil, better soil-moisture relationships, greater plant vigor, and more herbage the following season. To attain proper forage use, the number of livestock must be adjusted to match fluctuations in forage production.

Stocking rates have been set so as to use about half and leave about half the annual production of the key forage plants. The rates have been adjusted from year to year (table 2). As the range improved from 1943 to early in the 1950's, the stocking rate per unit of area was increased. When the severe drought of the 1950's began to reduce forage production, the rate was decreased.

TABLE 2.--Livestock use on the project area

Year	Area used	Animals	Months	Animal-unit months	Area per animal	Area per animal-unit month
	Acres	Number	Number	Number	Acres	Acres
1943	18,000	676	5	3,382	26.6	5.3
1944	20,000	890	5.33	4,746	22.5	4.2
1945	21,240	1,421	5.5	7,814	14.9	2.7
1946	29,598	2,063	5.66	11,677	14.3	2.5
1947	35,391	2,056	5	10,280	17.2	3.4
1948	45,631	2,478	6	14,871	18.4	3.1
1949	54,597	3,036	6	18,215	18.0	3.0
1950	54,597	2,769	6	16,615	19.7	3.3
1951	67,578	4,873	6	29,238	13.8	2.3
1952	68,298	5,605	6	33,632	12.2	2.0
1953	90,625	3,798	6	22,789	23.9	4.0
1954	90,625	3,621	6	21,726	25.0	4.2
1955	94,218	3,608	5	18,040	26.1	5.2
1956	80,885	1,999	4	7,995	40.5	10.1
1957	78,446	2,147	5	10,737	36.5	7.3
1958	66,662	1,891	5.5	10,400	35.3	6.4
1959	90,500	2,557	6	15,342	35.4	5.9
1960	94,000	2,916	6	17,496	32.2	5.3
1961	96,140	3,236	6	19,416	29.6	4.9

SEASON OF USE

The greatest need for grazing in this area is in the summer months, the primary growth period of warm-season grasses. Use during this period is not damaging to these grasses if grazing does not start too early, if the number of cattle is adjusted to the forage available, and if other essential management practices are carried out.

In 1943 grazing started May 1 and grazing permits were issued for a 5-month period. This starting date proved satisfactory during the first years of the project. To be correct, the starting date must be based on the range readiness of the primary forage species. Since 1950 the starting date has been delayed, usually until mid-May. In 1956 grazing was delayed until June 7.

Because of the 1944-47 experience, it was decided that the season of use could be extended for an additional month without depleting the ground cover and mulch needed to protect the soil and to retain moisture. In 1948 grazing permits were issued at the start of the season for 6 months. At the end of this period, permits were extended until mid-November when a blizzard made it necessary to remove all stock. On the basis of this experience, the grazing

Range seeding on hard land 1 year after planting.

Range seeding on hard land 3 years after planting. Grazed lightly in second year and used for 4 months in third year.

association decided not to plan for more than a 6-month grazing season.

A 6-month season was the rule until 1954, when the effects of drought reduced forage production and made it necessary to shorten the grazing season. In 1955 the grazing season was 5 months; in 1956, 4 months; and in 1957, 5 months.

Wide fluctuations in climatic conditions are reflected in equally wide variations in forage production. Adjustments in the starting date and length of a grazing season are vital to the maintenance of a soil-protecting stand of grasses and to the vigor of the key grass species.

Even these adjustments are not always enough. Complete rest for 1 year or more may be necessary. The decision to graze or to rest a pasture is based on the results of the current season's use and on the amount of forage left unused at the end of the season.

KIND OF LIVESTOCK

In deciding on the kind of livestock to permit in the area, primary consideration was given to the effect of the animals on the range. The most stable vegetation here is grass. Some grasses are better suited to use by cattle than by sheep. Sheep prefer succulent forbs or the tender growth of young grass, and they tend to patch-graze this kind of range. For this reason, it was decided that grazing use would be limited to cattle.

A cow-calf operation was considered the most stable operation, and at the outset in 1943 permittees were allowed to run only a cowherd on the project. It soon became apparent that this was neither practical nor economically sound since grazing allotments were small and most of them were not fenced separately. It was evident that for a livestock operation to survive in this area it must be flexible. In 1944 the policy was changed to allow permits for grazing steers as well as cows.

Trends in vegetation

The improvement or maintenance of vegetation on this land has always been one of the main objectives of this project. To a considerable degree trend in vegetation is a measure of the success of the work.

STUDY SITES

To measure and record the changes in vegetation, 21 permanent line transects each 25 feet long were established during the summer of 1953. A series of three lines was established at each of seven locations. The methods used were those described by Canfield.[2] The vegetation was measured in July 1953, April 1958, October 1959, and September 1962.

These measurements show some of the effects of a serious drought (1952-57) on the herbaceous vegetation. Those taken in July 1953 record the kind and amount of vegetation when the drought began. Those taken in April 1958 show the vegetation when the drought ended. Measurements in October 1959 indicate initial recovery from drought, and those in September 1962 show the vegetation after full recovery from drought.

Two plots were destroyed during the period of study. Data from the other five locations are summarized and discussed in the following pages.

Location I.--A sandy-land range site seeded to a mixture of cool-season grasses in the fall of 1945. Sand sagebrush was not eradicated, and no control method was used before seeding. The seed mixture consisted of one-third each (on the basis of bulk pounds of seed) western wheatgrass, crested wheatgrass, and Canada wildrye.

In 1953, 7 years after seeding, almost none of the seeded grasses remained and generally nothing indicated that this land had been seeded (table 3). The severe drought eliminated the perennial herbaceous vegetation. Sand dropseed and sand lovegrass survived the drought through dormant seed that germinated when moisture conditions improved. By 1962 the amount and kind of vegetation were much the same as before the drought. There was no crested wheatgrass, an exotic, which had been present in small amounts before the drought.

TABLE 3.--Perennial herbaceous vegetation at location I

Plant	July 1953		April 1958		October 1959		September 1962	
	Ground occupied	Composition	Ground occupied	Composition	Ground occupied	Composition	Ground occupied	Composition
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Sand dropseed.....	2.15	52	---	---	0.77	32	2.79	69
Sand lovegrass.....	1.08	26	---	---	.19	8	1.12	27
Western wheatgrass....	.17	4	---	---	.05	2	.07	2
Crested wheatgrass....	.15	4	---	---	---	---	---	---
Sand paspalum.....	.56	14	---	---	.04	2	---	---
Falsebuffalograss.....	.01	T	---	---	---	---	---	---
Sedge sp.....	.01	T	---	---	1.32	56	.08	2
Total.....	4.13	100	0.00	---	2.37	100	4.06	100

[2] Canfield, R. H. Application of the line interception method in sampling range vegetation. J. Forestry 39: 388-394. 1941.

In addition to the perennial herbaceous plants listed in table 3, sand sagebrush was an important component of the vegetation. The amount of sand sagebrush was determined by measuring the crown spread intercepted by a transect line. The proportion of ground occupied by sand sagebrush was 11.07 percent in 1953, 4.04 percent in 1958, 11.19 percent in 1959, and 4.71 percent in 1962. Because the points of measurement were not the same, these data are not included in table 3.

Location II.--A sandy-land range site seeded to a mixture of warm-season grasses in the spring of 1944. This site had once been cropped, and no sand sagebrush was growing on it. The seed mixture consisted of sand bluestem, little bluestem, sand lovegrass, sideoats grama, and blue grama. Seed was drilled into sorghum stubble. The seeding methods and mixture used here very nearly reestablished the kind of vegetation that is climax for this site (table 4). The stability of this vegetation, especially the dominant sand bluestem, indicates that a balance between site and vegetation has been reached.

Small soapweed also grows at this location. The proportion of ground occupied by small soapweed as determined by the crown-intercept method was 2 percent in 1953, 2.17 percent in 1958, 6.32 percent in 1959, and 3.07 percent in 1962.

TABLE 4.--Perennial herbaceous vegetation at location II

Plant	July 1953		April 1958		October 1959		September 1962	
	Ground occupied	Composition	Ground occupied	Composition	Ground occupied	Composition	Ground occupied	Composition
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Sand bluestem	3.53	65	4.35	82	4.21	81	4.33	79
Indiangrass	.04	1	---	---	.11	2	.35	6
Little bluestem	---	---	.12	2	---	---	.04	1
Sand lovegrass	.81	15	.36	7	.41	8	.65	12
Sand dropseed	.07	1	---	---	.13	2	.08	1
Blue grama	1.01	18	.48	9	.35	7	.05	1
Total	5.46	100	5.31	100	5.21	100	5.50	100

Location III.--A sandy-land range site seeded to a mixture of cool-season grasses in the fall of 1947. Sand sagebrush was not eradicated, and no control was attempted before seeding. The seed mixture consisted of one-third each western wheatgrass, crested wheatgrass, and Canada wildrye.

Range seeding composed mostly of sand bluestem. Location II (sandy land) of line-intercept study.

In 1953, 5 years after seeding, the dominant grass was crested wheatgrass. The severe drought completely eliminated this grass, and there was no reestablishment by September 1962. Sand dropseed withstood the drought better at this location than at either location I or II, which indicates that moisture conditions were slightly better here. Sand lovegrass was only a trace species before the drought and made no reentry (table 5).

Small soapweed and sand sagebrush also grow at this location. As determined by the crown-intercept method, the proportion of ground occupied by soapweed was 3.20 percent in 1953, 4.36 percent in 1958, 4.85 percent in 1959, and 3.33 percent in 1962; by sand sagebrush, none in 1953 and 1958, 1.88 percent in 1959, and 1.87 in 1962.

TABLE 5.--Perennial herbaceous vegetation at location III

Plant	July 1953		April 1958		October 1959		September 1962	
	Ground occupied	Composition	Ground occupied	Composition	Ground occupied	Composition	Ground occupied	Composition
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Crested wheatgrass	7.40	83	0.15	5	---	---	---	---
Sand dropseed	1.48	17	3.07	94	5.83	100	3.44	100
Sand lovegrass	.05	T	---	---	---	---	---	---
Tumblegrass	---	---	.03	1	---	---	---	---
Total	8.93	100	3.25	100	5.83	100	3.44	100

Location IV.--A hard-land range site seeded to a mixture of warm-season grasses in the spring of 1945. The seed mixture consisted of blue grama, buffalograss, sideoats grama, and sand lovegrass.

In 1953, 8 years after seeding, the reseeded species made up less than one-fifth of the vegetation (table 6), partly because of a poor initial stand. In earlier studies of this area, Cornelius and Atkins reported the poor establishment of the seeding made in 1945.[3] The short-lived perennial, tumblegrass, acted here much as it does on abandoned cropland. In their study of succession on abandoned farmland in western Nebraska, Judd and Jackson found tumblegrass abundant where the land had not been cropped for 7 years.[4] Indications are that the initial establishment was not good enough to control weeds and that the plot went through most of the steps of natural plant succession. A few blue grama and buffalograss plants were established, but it was between 8 and 13 years before blue grama became dominant.

TABLE 6.--Perennial herbaceous vegetation at location IV

Plant	July 1953		April 1958		October 1959		September 1962	
	Ground occupied	Composition	Ground occupied	Composition	Ground occupied	Composition	Ground occupied	Composition
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Blue grama	0.49	17	8.09	84	10.85	75	20.65	75
Buffalograss	.03	1	.41	4	1.72	12	5.93	21
Western wheatgrass	.04	1	.21	2	.07	1	.39	1
Sand dropseed	.31	11	.88	9	.88	6	.77	3
Sand lovegrass	.01	T	---	---	---	---	---	---
Tumblegrass	2.05	70	.04	1	.23	2	---	---
Total	2.93	100	9.63	100	13.75	100	27.74	100

[3] Cornelius, Donald R., and Atkins, M. Donald. Grass establishment and development studies in Morton County, Kansas. Ecology 27: 342-353. 1946.

[4] Judd, B. I., and Jackson, M. L. Natural succession of vegetation on abandoned farmlands in the Rosebud soil area of western Nebraska. Agron. J. 31: 541-547. 1939.

Location V.--A hard-land range site seeded to a mixture of warm-season grasses in the spring of 1942. The seed mixture consisted of blue grama, 9.6 pounds (bulk pounds per acre); sideoats grama, 2.3 pounds; galleta, 2.3 pounds; buffalograss, 1.6 pounds; sand dropseed, 0.5 pound; and weeping lovegrass, 0.25 pounds. The seed was drilled into good sorghum stubble.

In 1953, 11 years after seeding, the vegetation had much the same appearance as climax for this site (table 7). Success was due, at least in part, to a good initial stand. Cornelius and Atkins reported that good stands were obtained in 1942 also.[5] In addition to quick establishment, the stand has stability as proved during the drought. Sand dropseed and weeping lovegrass did not become established or were eliminated by competition before 1953. Galleta, a drought-tolerant native of the arid plains and deserts to the west and south, has increased, especially during the last few favorable years. Galleta is less palatable to cattle than the grama grasses, and this is a factor in its increase.

TABLE 7.--Perennial herbaceous vegetation at Location V

Plant	August 1953		April 1958		October 1959		September 1962	
	Ground occupied	Composition	Ground occupied	Composition	Ground occupied	Composition	Ground occupied	Composition
	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
Sideoats grama	3.88	52	2.75	42	4.85	49	4.11	38
Blue grama	2.83	38	2.61	39	3.41	34	3.17	30
Hairy grama	.15	2	---	---	.08	1	.08	1
Galleta	.61	8	.45	7	.96	10	2.45	23
Buffalograss	---	---	.80	12	.65	6	.87	8
Total	7.47	100	6.61	100	9.95	100	10.68	100

[5] Cornelius and Atkins, op. cit.

Discussion

The trials and results described here have not come from the effort of any one individual or organization. When the trials were started, the immensity of the rehabilitation job in the Great Plains called for the best efforts of all people interested in the welfare of the region and the Nation. During the period of grass reestablishment, the Soil Conservation Service was assisted by the Bureau of Plant Industry and the Kansas Agricultural Experiment Stations in planning the trial plantings and in evaluating the results of the early seedings. Local cooperation, especially through the Morton County Grazing Association, was good.

The results obtained have helped point the way to a method of stabilizing land and reestablishing permanent vegetation in the Great Plains. No single method is always successful, but much has been learned here about reseeding land to grass and managing it to maintain the production potential. Some of the ways to improve the chances for reestablishing and maintaining a permanent plant cover follow.

1. Provide a noncompetitive mulch as ground cover in which to seed.
2. Use seed of local origin or proved adaptation to the locality and site.
3. Place seed in a firm seedbed; disturb the mulch as little as possible.
4. Protect new seedlings from close clipping or grazing for 2 years or more after seeding.
5. Use the reestablished grass so as to maintain plant vigor.
6. Be prepared to adjust stocking rates to meet the fluctuations in forage production that are characteristic of this climate.

List of Plant Names[6]

Common name	Scientific name
Grasses	
bluestem, big	Andropogon gerardi
bluestem, caucasian	Andropogon caucasicus
bluestem, little	Andropogon scoparius
bluestem, sand	Andropogon hallii
bluestem, Turkestan	Andropogon ischaemum
broomcorn	Sorghum vulgare var. technicum
buffalograss	Buchloe dactyloides
dropseed, sand	Sporobolus cryptandrus
falsebuffalograss	Munroa squarrosa
galleta	Hilaria jamesii
grama, blue	Bouteloua gracilis
grama, hairy	Boutaloua hirsuta
grama, sideoats	Bouteloua curtipendula
indiangrass	Sorghastrum nutans
johnsongrass	Sorghum halepense
lovegrass, sand	Eragrostis trichodes
lovegrass, weeping	Eragrostis curvula
needleandthread	Stipa comata
needlegrass, green	Stipa viridula
paspalum, sand	Paspalum stramineum
ricegrass, Indian	Oryzopsis hymenoides
sandbur	Cenchrus pauciflorus
sorghum	Sorghum vulgare
sudangrass	Sorghum sudanense
switchgrass	Panicum virgatum
tumblegrass	Schedonnardus paniculatus
wheatgrass, crested	Agropyron desertorum
wheatgrass, intermediate	Agropyron intermedium
wheatgrass, tall	Agropyron elongatum
wheatgrass, western	Agropyron smithii
wildrye, Canada	Elymus canadensis
Other plants	
blueweed	Echium vulgare
camphorweed	Heterotheca subaxillaris
horseweed	Conyza canadensis
lettuce, wild	Lactuca sp.
loco, woolly	Astragalus mollissimus
pigweed	Amaranthus sp.
puncturevine	Tribulus terrestris
ragweed, western	Ambrosia psilostachya
russianthistle	Salsola kali
sagebrush, sand	Artemisia filifolia
sedge sp.	Carex sp.
soapweed, small	Yucca glauca
sunflower, common and prairie	Helianthus annuus and H. petiolaris

[6] Anderson, Kling L. Common names of a selected list of plants. Kans. Agr. Expt. Sta. Tech. Bull. 117. 59 pp. 1961.